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Progress Report for the Washington Department of Ecology

Title: Direct Seeding into Heavy Irrigated Cereal Stubble Instead of Burning

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Grower Advisors: *Neil Fink, Clark Kagele, Jefff Schibel, Keith Schafer, and Gary Schell are deep-well irrigators in east-central Washington. John Aeschliman and Perry Dozier are dryland producers in the high-precipitation zone, and Ron Jirava in the low-precipitation zone, of Washington. These growers actively encouraged this research and helped design the project. They are serving as advisors throughout the life of the project.*

Abstract of Research Findings

An irrigated cropping systems study was initiated in 2000 at the WSU Dryland Research Station at Lind. The crop rotation is 3-year winter wheat - spring barley - winter canola sown *i*) directly into standing stubble, *ii*) after mechanical removal of stubble, or *iii*) after burning the stubble. The traditional practice of continuous annual winter wheat sown after burning and moldboard plowing is also included as a check treatment. Second year (2002) grain yields averaged across residue and soil management treatments were 105 bu/a for winter wheat, 2.27 t/a for spring barley, and 2305 lb/a for winter canola. There were no significant yield differences within any crop as affected by residue management. Soil DNA analysis showed that risk of several diseases of winter wheat was low to moderate in all treatments. *Pratylenchus neglectus* (nematodes) was greatest in burn/plow and *Fusarium pseudograminearum* greatest with in standing stubble. Annual analysis of soil show that soil quality in no-till plots (without burning) is increasing rapidly compared to burn and burn/plow treatments.

Objectives

The objective of this long-term (6-yr) project is to determine the feasibility of direct seeding into high levels of residue as a substitute for burning in irrigated cropping systems. Specific objectives are to:

1. Test a 3-yr crop rotation of winter wheat - spring barley - winter canola. Crops are sown with a Cross-slot no-till drill into (i) standing stubble, (ii) after mechanical removal of stubble, and (iii) after burning the stubble. An additional treatment of annual winter wheat sown after stubble burning + moldboard plowing (sown with a double-disk drill) is included as a check.
2. Evaluate and develop effective techniques for sowing crops into heavy surface stubble using no-till methods.

3. Document cumulative effects of a diverse no-till crop rotation under three stubble

management practices on soil physical and biological properties, water use efficiency, diseases, weed ecology, and farm economics. Compare these effects to those under the check treatment (i.e., continuous winter wheat after stubble burning + moldboard plowing).

Materials and Methods

This study was initiated on 10 acres of prime cropland at the Washington State University Dryland Research Station at Lind. To obtain baseline residue levels to begin the experiment, the entire 10 acres was planted uniformly to Madsen winter wheat in September 1999. Grain yield (harvest August 2000) was 110 bu/a and straw production exceeded 10,000 lb/a.

Beginning in the 2001 crop year, a 3-yr crop rotation of winter wheat - spring barley - winter canola was grown under three stubble management methods. These are planting crops: *i*) directly into standing stubble, *ii*) after mechanical removal of stubble (i.e., after swathing and bailing), and *iii*) after burning of stubble. A check treatment of continuous annual winter wheat sown after stubble burning + moldboard plowing is also included. The experimental design is a modified split plot with four replications. Each portion of the 3-yr no-till crop rotation in each stubble management method is sown each year. Thus there are 40 plots (3 crops x 3 stubble management practices + the check continuous winter wheat x 4 replications).

Results and Discussion

Excellent stands of all crops were generally achieved using the Cross-slot drill for no-till plots and a double-disk drill for the burn/plow. However, winter canola stands were sparse in a few of the drill passes through standing barley stubble. Through trial and error, we now know that the Cross-slot openers must be in the ground before entering standing stubble plots (instead of trying to push the openers through heavy residue). Accordingly, all winter canola plots for the 2003 crop year had excellent stands. A complete list of field operations in this experiment was reported in the 2001 PM-10 Project report and is not repeated here.

Similar to 2001, there were no within-crop grain yield differences in 2002 as affected by residue management treatment (Table 1). Spring barley and winter canola were hurt by late spring frost, whereas winter wheat generally escaped frost damage. Soil water content in all 40 plots is measured to a depth of six feet just after harvest and again in April (water data not shown).

Tim Paulitz assessed plant disease. In early April 2002, soil samples were taken between the rows of growing winter wheat. Soil samples were air dried and then sent to Australia for DNA analysis for *Pratylenchus neglectus* (nematodes), *Rhizoctonia solani* AG-8, Take All, *Fusarium culmorum*, and *Fusarium pseudograminearum* (Table 2). *Pratylenchus neglecutus* was detected at significantly higher levels in burn/plow, whereas fusarium was greatest in the standing stubble and mechanically removed (i.e., non burned) treatments.

In October 2002, winter canola in the standing residue management treatment became diseased. Canola samples showed pythium disease (possibly a new species) as well as heavy infestation of rhizoctonia. All winter canola was subsequently 'winter killed' by 4^{0}F temperatures in late October.

Table 1. Grain yields of winter wheat, spring barley, and canola in 2001 and 2002 as

operation using a drill equipped with Cross slot openers. This is a minimum disturbance drill intended to maximize any effects of surface residues and treatment differences.

Prior to harvest of the spring wheat, we identified sites within the standing spring wheat of unusual density and marked these by global positioning (GPS). GPS-referenced sites are also identified across the entire experimental site based on random positioning within a grid. All data will be collected from these GPS referenced sites, including stand counts, Haun ratings on size and tillering of plants, yields, biomass production, grain protein, and disease and weed pressures. The fall-sown wheat is currently in about the 3-leaf stage and is ready for stand counts as soon as the weather permits.

2 **Cunningham Agronomy Farm Project No. 2—Winter Wheat Straw Management for Production of Alternative Crops Without Burning.**

This project is similar to No. 1 described above, but uses small plots (16 x 20 ft) within a field of winter wheat stubble planted to winter barley. Three replicates of six treatments include 1) stubble cut at the standard height (15-18 in.) with no further treatment (control); 2) as 1) and then stubble trimmed to 6-8 in. with a mower and harrowed; 3) as 1) with stubble trimmed but not narrowed; 4) as 1) but stubble harrowed and not trimmed; 5) as 1)but stubble burned and 6) as 1) but stubble and soil fumigated with methyl bromide. The winter barley was direct seeded uniformly over these plots with fertilizer applied below the seed, in one-pass using our Great Plains drill. The winter barley is also now in the three-leaf stage ready for stand counts. Later in the spring, we will do Haun ratings and tiller counts to assess the vigor and size of the plants in response to these treatments. The primary intent of this study is to determine whether there is any advantage agronomically of harrowing, cutting the stubble short, or both. The burn and fumigated treatments are essentially additional checks on effects of straw of soilborne pathogens.

2. **Cunningham Agronomy Farm Project No. 3—Crop Rotations as Alternatives to Burning for Root Disease Management on Wheat.**

The project No. 3 will not start until spring planting when hard red spring wheat will be planted on 30 acres where six alternative (rotation) crops were grown in 2002 as roughly six, 5-acre fields in strips within the 30-acre site. Soil samples will be taken in the spring for DNA tests to quantify the amount of each of several soilborne pathogens present after each of the six alternative crops. The six alternative crops were winter and spring barley, winter and spring canola, and winter and spring peas. We will also do measurement of Haun and tiller numbers for the spring wheat within each of 25 GPS reference sites for each alternative crop, followed by yield, protein, biomass, and disease assessments.

We were able to obtain information on the effects of the three alternative spring crops (spring barley, spring canola, and spring peas) used as rotation crops on the growth and yield of spring wheat in 2002, as well as data on the effects of these rotation crops on the incidence and severity of fusarium crown rot that was present in the spring wheat in 2002. We found that the Haun ratings and number of tillers as well as yield (Tables 1

To: Mr. Jon Jones
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Subject: DOE PROJECT—INTERIM REPORT

Date: February 18, 2003

Title: **Straw Management and Crop Rotation Alternatives to Burning Wheat Stubble**

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Cooperator: William Schillinger, WSU

Associate in Research: Shawn Weterau

Funding period: June, 2002—May, 2003

Report presented in sequence of the four proposed projects:

1. **Cunningham Agronomy Farm Project No. 1—Spring wheat Straw Management for Production of Winter Wheat Without Burning.**

This study was initiated as proposed, with four replicates of four straw management treatments imposed on spring wheat stubble immediately after harvest, followed by direct seeding winter wheat nearly two months later (seeding was delay and emergence delayed ever more by the dry fall). The four straw management treatments are: 1) stubble cut at a standard height of 15-18 inches with no further treatment (control); 2) stubble cut short (6-8 inches) with no further treatment; 3) stubble cut at a standard height and then trimmed to 6-8 inches height and harrowed using the Combs heavy harrow with a cutter bar; and 4) stubble cut standard height and then harrowed with the Combs heavy harrow without use of the cutter bar. Each of these straw management treatments are 120 feet wide and up to 500 feet long, and extend parallel to one another up a south-facing slope and over a ridge. Within the four control plots, we set up three small plots (each 16 x 16 feet square) of straw burned, straw and soil fumigated with methyl bromide under a clear plastic tarp, and no treatment (control). The entire field site, including the burned and fumigated plots within the control strips were seeded and fertilized as a one-pass

affected by various stubble and soil management practices.

	Winter Wheat (bu/a)		Spring Barley (ton/a)		Winter Canola (lb/a)	
	2001	2002	2001	2002	2001[A]	2002
Stubble burned	85	106	2.88	2.21	2574	2502
Stubble mechanically removed	67	110	3.03	2.33	2486	2226
Standing Stubble	69	107	2.88	2.26	2282	2188
Burn and Plow	75	97				
LSD (0.05)	NS	NS	NS	NS	NS	NS

NS = no significant differences at the 5% probability level.
A: spring canola instead of winter canola in 2001.

Table 2. Effect of tillage and residue management on soil DNA levels of several plant pathogens in winter wheat. Data from Tim Paulitz, USDA-ARS.

	Pratylenchus neglectus	Rhizoctonia solani AG-8	Fusarium	Take-All
	DNA (pg/g soil)			
Stubble burned	12 b	70 a	11 a	21 a
Stubble mech. Removed	16 b	80 a	52 ab	19 a
Standing stubble	18 b	72 a	83 b	18 a
Burn & plow	49 a	31 a	16 ab	30 a

[x] Within-column averages followed by the same letter are not significantly different at the 5% probability level.
pc/g = picograms/gram

Weed species in 2002 included prickly lettuce, mares tail, tansy mustard, downy brome, as well as small populations of pepper weed, oyster plant, mayweed, and star thistle. The only significant difference in weed populations as affected by crop or residue management was in downy brome (Table 3). There was essentially no downy brome present in any plot that had been burned, or in winter canola (where Assure II herbicide was used). Small downy brome populations were present in winter wheat and spring barley in the standing stubble and stubble mechanically removed plots.

Table 3. Population of four weed species in winter wheat, spring barley, and winter canola in 2002 as affected by residue management.

		Weeds (per 3 m^2)				
Crop	Residue Management	Prickly Lettuce	Mares-tail	Tansy Mustard	Downy Brome	Total[x]
Winter Wheat	Burn/Plow	0	0	0	0 d	0
Winter Wheat	Burned	5	18	1	1 cd	26
Winter Wheat	Mech. Removed	4	14	2	12 a	32
Winter Wheat	Standing	4	7	1	4 bcd	16
Spring Barley	Burned	7	2	2	0 d	13
Spring Barley	Mech. Removed	12	7	1	9 ab	30
Spring Barley	Standing	5	6	0	7 abc	18
Winter Canola	Burned	3	4	4	0 d	11
Winter Canola	Mech. Removed	5	3	5	0 d	16
Winter Canola	Standing	3	1	13	0 d	22
		NS	NS	NS		NS

Within-column averages followed by the same letter are not significantly different at the 5% probability level.
[x]Includes small populations of pepperweed, oyster plant, mayweed and star thistle.

Publications and Presentations (2002 only)

Published Abstracts

Schillinger, W.F., T.C. Paulitz, and A.C. Kennedy. 2002. Direct seeding into heavy irrigated cereal stubble instead of burning. Soil Science Society of America annual meeting 11-14 Nov., Indianapolis, IN. [CD-ROM]. *ASA, CSSA, and SSSA Abstracts*.

Experiment Station Research and Extension Reports

Schillinger, W., H. Schafer, B. Sauer, T. Paulitz, A. Kennedy, D. Young, A. Kennedy, S. Schofstoll, D. Wysocki, K. Saxton, B. Fode, K. Schroeder, and C. Claiborn. 2002. Irrigated cropping systems research at Lind. pp. 96-99. In: *2002 Field Day Proceedings: Highlights of Research Progress*. Department of Crop and Soil Science Technical Report 02-1, Washington State University, Pullman, WA.

Field Days, Presentations, and Advisory Meetings

This project was shown and discussed by Schillinger to 170 people at the Lind Field Day on June 13, 2002. The field project was also shown informally to numerous groups and individuals. Presentations on this project were made to 40 people at the University of Idaho Canola Working Group meeting in Moscow on March 4, 2002. The annual researcher-grower advisory meeting for this project was held at Lind on November 26, 2002 (15 attended).

and 2), and incidence of fusarium crown rot (Table 3) was the same regardless of the previous crop. These are the kinds of data we will be taking from straw residue management treatments during 2003.

Table 1. Effect of Rotation Crops on Growth and Yield of 'Hank' HRS, Cunningham Agronomy Farm, 2002

	Previous Spring Crop		
Crop Response	Canola	Peas	Barley
Haun Rating* (June, 11)	6.6	6.5	6.2
Grain Yield (bu/A)	66.6	65.6	64.2

* Indicates the number of leaves on the mainstem, e.g., 6.6 = six fully developed leaves and the seventh leaf is 60% out.

Table 2. Effect of Rotation Crops on Tillering of 'Hank' HRS, Cunningham Agronomy Farm, 2002

	% Plants per Previous Spring Crop		
Tiller	Canola	Peas	Barley
	%	%	%
T-0	34.2	20.9	38.4
T-1	85.0	72.3	82.3
T-2	48.3	54.5	53.8
T-3	10.0	20.0	9.2
T-4	0.8	0.9	0.8

Table 3. Effect of Rotation Crops on Fusarium Crown Rot Severity in DNS with and without Nitrogen Fertilizer

Prior Crop	% Plants per Rating Category*			
	nil	*mild*	*mod*	*severe*
Residual nitrogen only				
Canola	60	31	8	0
Peas	73	19	7	0
Barley	70	25	4	0
Fertilized with 190 lbs N/A				
Canola	45	36	16	2
Peas	51	31	16	1
Barley	43	39	15	2

* Rating categories of nil, mild, mod[erate] and severe indicate the extent to which the disease had progressed from the base upward into the stem. Severe, for example is a category where the disease extended two or three internodes up the stem.

4. Lind Research Station Project—Documentation of Wheat Straw Management and Rotation Alternatives to on Root Pathogen Populations Under Irrigation.

This project is part of another study funded by the Washington Wheat Commission, but with measurements of pathogens in the soil funded by this DOE project. The DNA test is a new test developed in Australia and used by farmers there to predict the risk of different root diseased of wheat and barley prior to planting. The test developed in Australia works beautifully for several Washington species and strains of wheat and barley root pathogens. The data below are for R. solani AG8, cause of bare patch and root rot of direct-seeded wheat and barley, and Fusarium pseudograminearum, cause of fusarium crown rot of wheat.

The data in Table 4 show that while the amount of R. solani AG8 was least in soil where the stubble had been burned and the land then plowed, the differences between this treatment and three other straw management treatments were not significant. Possibly these trends if continued will become significant, hence we will need to follow these measurements with additional measurements in 2003.

Table 4. Effect of Straw Management Treatments on DNA levels of of *R. solani* AG-8 in Soil Following Winter Wheat, Lind, 2002

Treatment	DNA (pg/g soil)		Risk
Burn & Plow	31	A	low
Mechanical Stubble Removal	80	A	med
Stubble Burned	70	A	med
Standing Stubble	72	A	med

Mean separation with Kruskal-Wallis Non-parametric Test

The data in Table 5 point more clearly to a significant trend of less pathogen inoculum with burning than not burning, and no benefit of mechanical removal of the stubble. Fusarium lives in the tillers but this is the first evidence that burning might lower the amount of inoculum. We have a large program on management of Fusarium crown rot, including by how the crop is fertilized with nitrogen. We are also testing varieties to find the most resistant/least susceptible. Any one of these methods of Fusarium control could become an alternative to stubble burning.

Table 5. Effect of Tillage Treatments on DNA Levels of *Fusarium pseudograminearum* in Soil Following Winter Wheat, Lind, 2002

Tillage Treatment	DNA (pg/g soil)		Risk
Burn & Plow	16	AB	low
Mechanical Stubble Removal	52	AB	med
Stubble Burned	11	A	low
Standing Stubble	83	B	med

Mean separation with LSD